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FLOW RESEARCH CO KENT WA

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THREE-DIMENSIONAL FLOW CALCULATION BASED ON EQUIVALENCE RULE.(U)

NOV 79 M HAFEZ

N00014-76-C-0880

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(9) Final Technical Report

ONR Contract No. N00014-76-C-0880

(6) Three-Dimensional Flow Calculation
Based on Equivalence Rule

By
(10) Mohamed Hafez

(11) November 1979

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Flow Research Company
A Division of Flow Industries, Inc.
21414 - 68th Avenue South
Kent, Washington 98031
(206) 854-1370

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				DATE		8. ACCEPTANCE POINT D	
2. SHIPMENT NO. FRC 155(ERTT)		3. DATE SHIPPED Nov. 27, '80		4. B/L TCN		5. DISCOUNT TERMS	
9. PRIME CONTRACTOR Flow Research Company, a Division of Flow Industries, Inc. 21414 - 68th Avenue South Kent, Washington 98031				10. ADMINISTERED BY DCASMA, Seattle Attn: CAO Terminal			
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13. SHIPPED TO Scientific Officer, Fluid Dynamics Program Mathematical & Information Sciences Division Office of Naval Research 800 North Quincy St., Arlington, VA 22217 Attn: R. D. Cooper Code 438				14. MARKED FOR Scientific Officer, Fluid Dynamics Program Mathematical & Information Sciences Division Office of Naval Research 800 North Quincy St., Arlington, VA 222 17 Attn: R. D. Cooper Code 438			
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March 24, 1980
80FI-200-C188

Mr. Morton Cooper
Code 430B (N00014)
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Reference: ONR Contract No. N00014-76-C-0880

Dear Mr. Cooper:

With reference to subject contract and our telephone conversation this morning, I have enclosed the form DD-250 which was to have accompanied our final report submittal last November 1979. My understanding, after talking with you, is that the final report has been technically accepted.

I will be looking forward to receiving a signed copy of the DD-250.

Sincerely,

Mary Chandra
Contract Administrator

MC/vm

Enclosure - as stated

cc: Margaret Stinson - ACO
ONR Branch Office
J. Mercer

FLOW RESEARCH COMPANY A DIVISION OF FLOW INDUSTRIES INC.

HEADQUARTERS *** 21414 80th AVENUE SOUTH, KENT, WASHINGTON 98031 *** PHONE (206) 854 1370 SEATTLE EXCHANGE 622 1600 *** TELE 917 447 2702

ONR Contract N00017-76-C-0080

Transonic flows around three-dimensional configurations are calculated based on the artificial compressibility method. The transonic nonlinear mixed-type equation is treated as if it were elliptic, and the artificial viscosity is added implicitly through modifying the density. Thus, standard discretization techniques and standard iterative procedures are applicable.

The output of the full three-dimensional code are compared to the results of numerical implementation of two asymptotic theories; transonic equivalence rule and transonic lifting line. While the analytical asymptotic theories are limited to low or high aspect ratio configurations, it is found that the numerical algorithms based on these concepts can be employed efficiently in a wider range than the range where the asymptotic theories are strictly valid.

Equivalence Rule:

It is shown that for wings of small leading edge sweep angle, departure from the Whitcomb-Oswatitsch area rule is significant. For sufficiently large or moderate leading edge sweep angles, however, the agreement is satisfactory. Drag-rise and outer flow field are presented for a number of cases and their equivalent bodies. Nonlinear lift corrections to the classical area rule are examined. There seems to be good agreement between calculated flows around equivalent wing-body combinations with the same wing planform for cases with appreciable lift.

Lifting Line:

Corrected two-dimensional calculations, taking into consideration the three-dimensional upwash and sweep effects, compare favorably with the full three-dimensional calculations except at the root and tip sections of the wing as expected.

To calculate flows around complicated geometries using the above codes, the following procedures are used. In the first case, a sequence of cross flow solutions are computed, plus three-dimensional corrections obtained from flows around equivalent but simple three-dimensional configurations. In the second case, the inner limit of three-dimensional flows around a simple equivalent wing is used as an outer boundary for a sequence of two-dimensional calculations. Thus, the enforcement of body boundary conditions, as well as the grid generation, are relatively easy compared to the full three-dimensional calculations.

A Listing of Technical Reports

1. M. Hafez, "Numerical Evaluation of Transonic Equivalence Rule," Flow Research Report No. 127, presented at the 31st Meeting of the American Physical Society, November 1978.

Partial Support of:

2. M. Hafez, J. C. South, Jr., "Vectorization of Relaxation Methods for Solving Transonic Full Potential Equation," presented at GAMM Workshop on Transonic Flow Calculation, Stockholm, Sweden, September 1979.
3. M. Hafez, "Convergence Acceleration of Time-Dependent Methods for Transonic Flow Calculations," Flow Research Note No. 177, September 1979.

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